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(54) Title: LIGHTWEIGHT WALL CONSTRUCTION

(57) Abstract: A low or no fines lightweight concrete mixture. The mixture comprises one part by volume of a cementitious binder, 2-10 parts inert coarse aggregate, a cement additive in an amount of 0.05 to 0.3 % by weight of the cementitious binder and an effective amount of water, the additive including 40-99 % of a viscosity enhancing agent, which in water either dissolves or forms colloidal dispersions, and 1-60 % of an air entrainment agent/surfactant adapted to entrain air when mixed with water and/or pumped. The mixture is particularly suitable for constructing a building panel where a frame is prepared, the front and rear faces being covered by fibre reinforced cementitious sheets and the cavity there between at least partially filled with the lightweight concrete mixture which flows in a manner similar to loose fill.

TITLE: LIGHTWEIGHT WALL CONSTRUCTION

TECHNICAL FIELD

The present invention relates to cementitious articles and particularly but not only walls, floors and the like of lightweight construction.

BACKGROUND OF THE INVENTION

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

There have been many proposals in the past for a lightweight contemporary monolithic wall system to replace conventional masonry walls. Lightweight walling systems provide significant advantages over the prior art particularly the reduction in load placed on foundations.

This has proved particularly difficult for external walling systems which require equivalent durability and load bearing capacity to conventional masonry. The lightweight systems must also be highly resistant to damage from impact, thermally and acoustically efficient and suitable for application of different decorative finishes.

Traditional systems also require skilled labour. Many replacement systems strive to be quicker, simpler and less expensive to install and less dependent on skilled labour.

Off-site construction can produce lightweight wall or floor panels for subsequent installation on-site. Transportation costs with such systems, however, are significant. In situ building systems are preferred for various reasons. Transportation costs are reduced and the in situ systems are also more flexible in the type of wall or floor which can be constructed. The systems also allow services to be installed in the wall during construction rather than subsequent installation.

Such in situ construction of lightweight walls, for example, began with the so-called "dry wall system". This was a sandwich wall comprised of timber or steel framing with thin sheeting of gypsum or fibre reinforced cement attached thereto. The wall cavity remained hollow. The system was limited to internal partitioning, however, due to its very low load bearing capacity, lack of durability and low mass.

The applicant has previously proposed a system for constructing a wall in which a lightweight aggregate concrete slurry is pumped into the void formed between two fibre cement sheets supported on a frame. This system essentially requires the entire wall to be filled with the concrete slurry.

This system has proved quite efficient in terms of acoustic and thermal insulation, durability and masonry feel. It does, however, require substantial quantities of cementitious material. Additionally, since the cavity is essentially filled with a monolithic cementitious block, water cannot escape from inside the cavity wall.

The cost of lightweight aggregate is also quite high and in many cases is difficult to mix with a cementitious binder to provide a homogeneous mixture.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

DISCLOSURE OF THE INVENTION

In a first aspect, the present invention provides a lightweight concrete mix comprising 1 part by volume of a cementitious binder, 2-10 parts inert coarse aggregate, a cement additive in an amount of between 0.5-0.3% by weight of the cementitious binder and an effective amount of water,

the additive including 40-99% of a viscosity enhancing agent which in water either dissolves or forms colloidal dispersions, and 1-60% of an air entrainment agent/surfactant adapted to entrain air when mixed with water and/or pumped.

In a second aspect, the present invention provides a method of constructing a panel comprising erecting a substantially rigid frame, attaching to the frame front and rear fibre reinforced cementitious sheets to form a cavity there between and providing to the cavity a lightweight concrete loose fill comprising one part by volume of a cementitious binder, 2-10 parts inert coarse aggregate, a cement additive in an amount of between 0.5-0.3% by weight of the cementitious binder and an effective amount of water,

the additive including 40-99% of a viscosity enhancing agent which in water either dissolves or forms colloidal dispersions, and 1-60% of an air entrainment agent/surfactant adapted to entrain air when mixed with water and/or pumped.

The applicant has found that the use of a low or no fines concrete mixture for a building panel provides significant advantages over the prior art.

No fines concrete has previously been used to provide an external lightweight concrete wall. The procedure involved casting the concrete in conventional formwork, waiting for the mixture to cure, stripping the formwork and then rendering the wall surface. This last step was required since the no fines concrete wall is essentially filled with voids between the coated aggregate particles.

Several problems arose with such previous methods, however, including:

a) the need to maintain the formwork for extended periods (up to two weeks) until sufficient strength had been developed in the mixture. This was due to very little cohesion existing between the coarse aggregate particles since there were little or no fines to fill the gaps therebetween.

b) the no fines concrete had to be moist cured continuously for extended periods of time due to the limited volume of cement binder coating the coarse aggregate and its susceptibility to drying particularly in dry or windy conditions.

c) when used as external walling, this conventional wall was susceptible to moisture ingress from the outside due to the large volumes of connected pores existing in its honeycombed structure. As mentioned above, this could at least partially be remedied by rendering the inner and outer wall surfaces. Not only was this quite expensive, however, but it reduced the sound absorbing properties of the no fines concrete wall through closing of the surface pores and increasing its density.

The present applicant has found a novel mixture which allows the aggregate to bond well with each other and the FRC sheets on the frame, and overcomes or at least reduces some of the difficulties associated with conventional no fines concrete (NFC) by:

a) providing impact resistant wall skins to act as permanent formwork and avoid the need to wait for curing and subsequent removal of formwork;

b) providing the wall skins to protect the curing mixture in the wall cavity thereby avoiding the need for continuous moisture curing of the core;

c) providing a smooth outer surface with the wall skins to avoid the need for rendering, prevent moisture ingress and maintain the acoustic performance of the no fines cement core.

The strength of bonding between the no fines cement core and the wall skins of the inventive method is quite surprising. Conventional NFC mixes which contain such high volumes of coarse aggregate and relatively low cement contents are normally incapable of generating sufficient binder surface area in contact with the wall skins to enable bondability.

In a third aspect, the present invention provides a building panel comprising a substantially rigid frame defining front and rear faces, front and rear fibre reinforced cementitious sheets attached to the frame to form a cavity there between, the cavity being at least partially filled with a lightweight concrete loose fill,

wherein the lightweight loose fill comprises 1 part by volume of cementitious binder, 2-10 parts inert coarse aggregate, a cement additive in an amount between 0.05-0.3% by weight of the cementitious binder and an effective amount of water,

the additive including 40-99% of a viscosity enhancing agent which in water either dissolves or forms colloidal dispersions and 1-60% of an air entrainment agent/surfactant adapted to entrain air when mixed with water and/or pumped.

The front and rear fibre reinforced cementitious sheets may be attached to the frame by any method known in the art including gluing, screwing and stapling as disclosed in International Patent Application No. PCT/AU99/00639 which is incorporated herein by reference.

Due to the absence of fines in the cementitious binder, the resulting mixture is highly porous and is composed of coarse aggregate bound together with a thin cement paste. Not only does the resultant wall panel have excellent load bearing capacity, it is drainable due to the presence of 20%-40% by mix volume of interconnected pores, and is an excellent insulator due to such a high volume of pores within the mix. It may in fact be designed for its drainability for use as retaining wall on side slopes, for example.

The novel cementitious mixture may completely fill the wall cavity if desired. Alternatively, the wall cavity may be partially filled with the no fines concrete mix and the remainder left dry or filled with another material such as polystyrene concrete.

While not wishing to be bound by any particular theory, the applicant believes that the present inventive mixture provides enhanced core/skin interface bonding due to the additional chemical bonding contributed by the cement additive and the enhanced moisture retention in the cementitious binder in contact with the wall skins. This last

aspect reduces drying of the cementitious binder caused by moisture intake by the wall skin, and consequent debonding.

In addition, the inventive additive provides excellent bonding between the various aggregate particles. It is believed this is due, at least in part, to the additive providing efficient wetting of the aggregate particles, generation of a foamed cementitious binder in a volume sufficient to coat the coarse aggregate particles, and efficient retention of water in the cementitious binder.

The proportion of said viscosity enhancing agent ranges from about 40 to about 99, preferably from about 60 to about 90 and still more preferably from about 70 to about 85 parts by weight per 100 parts by weight of the blend.

The proportion of said air entrainer is an amount in the range of from about 1 to about 60, preferably from about 10 to about 50 and still more preferably from about 20 to about 40 parts by weight per 100 parts by weight of the blend.

The term "viscosity enhancing agent" as used herein includes one or more thixotropic agents which either dissolve in water or which at least form colloidal dispersions in the presence of water wherein the effect is to produce an increase in the viscosity of the water. These include cellulose derivatives, polysaccharides and synthetic hydrophilic polymers..

Examples of cellulose derivatives useful in the composition of this invention include hydroxymethylcellulose, hydroxyethylcellulose and hydroxy propyl methyl cellulose.

Examples of polysaccharides useful in the composition of this invention include starches and alginate.

Examples of synthetic hydrophilic polymers and copolymers useful in the composition of this invention include polyvinyl alcohol and polyethylene and polypropylene oxides.

The term "air entraining agent" (AEAs) refers to surface active agents (surfactants) which act to entrain air in the composition as it is mixed with water and/or pumped. AEAs used in the present invention may include one or more nonionic, cationic and anionic surfactants such as sodium salts of alpha olefine sulphonates and sodium lauryl sulphate or sulphonate.

The term "cementitious binder" as used herein, means all inorganic materials which comprise compounds of calcium, aluminium, silicon, oxygen, and/or sulfur which exhibit "hydraulic activity" that is, which set solid and harden in the presence of water. Cements of this type include common Portland cements, fast setting or extra fast setting, sulphate resisting cements, modified cements, alumina cements, high alumina cements, calcium aluminate cements and cements which contain secondary components such as fly ash, pozzolana and the like.

The term "cementitious binder" as used herein, also includes a material identified as slag and mixtures thereof with Portland cement.

The term "coarse aggregate" refers to the aggregate being inert with respect to other components of the mixture. It includes graded and ungraded aggregate such as washed river gravel, crushed igneous rock or limestone, lightweight aggregate, pumice, scoria, expanded shale (foamed clay) and other artificial aggregates, crushed hard-burnt clay bricks or air-cooled blast furnace slag. It preferably fits within the following criteria:

Size range:	5 mm to 20 mm,
Maximum % coarser than 20 mm size:	5%
Maximum % finer than 5 mm size:	10%

The ideal coarse aggregate grading is:

single size (gap graded), with highest proportion ranging between 10 mm to 20 mm.

containing minimum fines, preferably zero.

The load bearing capacity of the cured material is between approximately 5 to 20 MPa. To assist in load bearing, the lightweight cementitious material may include 0 to 40% of a thickener, high reactive pozzalanes, such as silica fumes, water sealing agents, water reducing agents, setting rate modifiers, hardeners, plasticisers or waterproofing agents.

The initial quantity of water in the cementitious loose fill will depend upon a number of factors including the type and content of other constituents. In most cases, a water to cement ratio of 0.3 to 0.8 and preferably 0.5 to 0.7 is sufficient to ensure pumpability of the loose fill and adhesion of the aggregate particles to themselves and the FRC sheets.

Unless the context clearly requires otherwise, throughout the description and the claims, the words 'comprise', 'comprising', and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

MODE(S) FOR CARRYING OUT THE INVENTION

So that the present invention may be more clearly understood it will now be described with reference to the following examples:

EXAMPLE 1:

Effect of cement additive addition in NFC mixes containing high aggregate volume on core/skin bonding

Three mix ratios representing NFC mixes that were mostly applied in prior art , ie 1:6, 1:8 and 1:9 by bulk volume of cement, were chosen. The mix design data corresponding to the three mix ratios are shown in Table 1.

Table 1: Mix design of NFC mixes with various mix ratios

NFC Mix	Mix Ratio (by vol.)	Porosity, %	Density kg/m^3	Cement Content per m^3 of mix	Agg. content per m^3 of mix
1:6 Mix					
Cement	1	27	1733	200	867
Aggregate	6				
W/C ratio	0.61				
1:8 Mix					
Cement	1	29	1667	155	894
Aggregate	8				
W/C ratio	0.64				
1:9 Mix					
Cement	1	30	1633	140	905
Aggregate	9				
W/C ratio	0.66				

Two sets of mixes were produced for each mix ratio using machine mixing. One set was conventionally produced as in prior. The other set contained the cement blend additive at the addition rates shown in Table 2.

Table 2: Cement additive addition rates in NFC mixes

Cement additive component	Material description	Addition rate
Organic polymeric material:	Cellulose ether	0.07% by weight of cement
Air entraining agent:	Anionic surfactant	0.03% by weight of cement

The mixing sequence was as follows:

a) Water and cement additive were added and allowed to mix and generate foam.

b) Coarse aggregate were batched and allowed to wet fully.

c) Cement was added and mixing was continued until all aggregate were coated with foamed cement mix.

Prototype sandwich composite walls (2400 mm long x 2400 mm wide x 100 mm thick) comprised of thin fibre reinforced cement skins fixed onto steel stud/track framing were built and wall cavities were filled with the various NFC mixes produced. The wall configurations and details of NFC mixes vs skin/core bond outcomes are shown in Table 3.

Table 3: Data corresponding to walls filled with various NFC mix ratios

Wall configuration			**NFC mix details**			**Skin/core**
Wall skin (commercial name) *	**Wall skin thickness (mm)**	**Steel stud spacing (mm)**	**NFC mix ratio (by vol. of bulk cement)**	**NFC mix density kg/m^3**	**Cement additive addition**	**bond outcomes**
Hardiflex Pro	6.0	450	1:6	1733	without additive	debonded
					with additive	bonded
Hardiflex Pro	6.0	450	1:8	1666	without additive	debonded
					with additive	bonded

Table 3 Continued

Hardiflex Pro	6.0	450	1:9	1633	without additive	debonded
					with additive	bonded
Hardiflex	4.5	450	1:6	1733	without additive	debonded
					with additive	bonded
Hardiflex	4.5	450	1:8	1666	without additive	debonded
					with additive	bonded
Hardiflex	4.5	450	1:9	1633	without additive	debonded
					with additive	bonded

(*) Cellulose fibre-reinforced cementitious sheet laminates (trade name: fibre cement)

Table 3 shows that NFC mixes containing coarse aggregate ranging between 6 to 9 by volume of bulk cement addition have failed to bond with the composite wall skins. This is expected as these mixes contain low cement contents (ranging between 200 kg/m^3 to 140 kg/m^3 of mix - Table 1) resulting in low cement paste / coarse aggregate volume ratios, ie limited cement paste volumes, which are unable to provide sufficient binder surface area at the skin/core interface to enable bonding.

On the other hand, the NFC mixes containing cement additive components at the addition rates shown in Table 2 were surprisingly able to bond well with the fibre-reinforced cementitious skins.

It is hypothesised that the presence of the cement additive in the mix enables:

a) efficient wetting of the coarse aggregate prior to cement addition.

b) generation of foamed cement paste in sufficient volume for coating the coarse aggregate in lean NFC mixes (cement content < 200 kg/m^3).

c) efficient water retention in the cement paste which reduces water deprivation in NFC mixes and consequent debonding due to water absorption by highly permeable FRC skins.

d) effective core/sheet bond in lean NFC mixes due to the bonding characteristics of the cement blend additive.

EXAMPLE 2

Pumpability of the NFC mixes containing cement blend additive

This test aims to produce NFC mixes that could be pumped into sandwich wall cavities to form a flat solid wall in which the core infill (NFC mix) is well-bonded with the sandwich fibre cement (FRC) skins.

NFC mix details

A 1:7 cement : aggregate volumeric mix ratio was chosen as a standard NFC core infill mix (cement content = 177 kg/m^3 of mix, aggregate content = 0.88 m^3/m^3 of mix). The cement blend additive was dosed at the addition rates shown in Table 4.

Five NFC mixes containing a wide range of aggregate types and sizes were investigated for pumpability, as shown in Table 5.

Table 4: Cement additive addition rate in the 1:7 NFC mix

Cement additive component	Material description	Addition rate
Viscosity enhancing agent:	Cellulose ether	0.09% by weight of cement
Air entraining agent:	Anionic surfactant	0.04% by weight of cement

Table 5: Details of 1:7 cement : aggregate (by volume) NFC mixes with various aggregate types and sizes

Mix Designation	Aggregate Type	Aggregate Max. Size (mm)	NFC Density (kg/m^3)	NFC Porosity (%)	Water/Cement ratio (by weight)
NFC 20 R	Rounded agg. (Nepean River)	20	1650	32	0.50
NFC 10 R	Rounded agg. (Nepean River)	10	1725	29	0.60
NFC 20 C	Crushed stone (Blue Metal)	20	1500	37	0.50
NFC 10 C	Crushed stone (Blue Metal)	10	1625	32	0.60
NFC 10 S	Lightweight volcanic agg. (Scoria)	10	1200	30	0.50

Wall configurations

Four (1.2 m wide x 2.4 m high) prototype sandwich walls lined with fibre cement (FRC) skins were built. They included two staple-fixed sandwich walls and two screw-fixed sandwich walls (configurations as shown in Table 6).

Table 6: Prototype wall configurations

Wall No.	Mix Designation	FRC Sheet Type (*)	Stud Type	Stud Spacing (mm)	Sheet Fixing Methodology	Mix Drop Height (mm)
Wall # 1	**NFC 20 R**	6.6 mm Hardiwall™	70 mm box section	400	Staple-fixed @ 100 mm c/c	2700
Wall # 2	**NFC 10 R**	6.6 mm Hardiwall™	70 mm box section	400	Staple-fixed @ 100 mm c/c	2700
Wall # 3	**NFC 10 S**	6.6 mm Hardiwall™	64 mm C-section	400	Screw-fixed @ 150 mm c/c	2700
Wall # 4	**NFC 20 C**	6.6 mm Hardiwall™	64 mm C-section	300	Screw-fixed @ 150 mm c/c	2700
Wall # 5	**NFC 10 C**	6.0 mm Hardiflex™	64 mm C-section	600	Screw-fixed @ 200 mm c/c	2700
Wall # 6	**NFC 10 C**	6.0 mm Hardiflex™	70 mm box section	400	Staple-fixed @ 200 mm c/c	2700
Wall # 7	**NFC 10 C**	4.5 mm Hardiflex™	70 mm box section	400	Staple-fixed @ 100 mm c/c	2700
Wall # 8	**NFC 10 C**	6.0 mm Hardiflex™	90 mm C-section	400	Screw-fixed @ 200 mm c/c	6000

(*) Cellulose fibre-reinforced cementitious sheet laminates (trade name: fibre cement)

The trial used a 200 litre tilting mixture to produce the five NFC mixes outlined in Table 5. The mixing sequence was as follows.

1. Water and the cement additive were added and allowed to mix and generate foam.
2. Course aggregate was then batched and allowed to wet fully.

3. Cement was added and mixing was continued until all aggregate were coated with the foamed cement mix.

Each mix was then pumped into the cavities in the various walls (outlined in Table 6) using a rubber hose of 50 mm diameter. The pump used was a pneumatic rotary dry mix spraying machine. This machine is designed for SHOTCRETE™ and GUNITE™ applications but it was speculated may be able to pump the NFC mix. The following potential difficulties, however, were identified in using such a machine to convey the NFC mixture:

a) Line blockage due to aggregate interlock and absence of finds in the NFC mix,

b) Back-spraying of the NFC mix and incomplete filing of the wall cavity due to the excessive thrust generated by the pneumatic rotary spraying machine, and

c) Blowing out of the FRC skins (especially the staple-fixed skins) due to the excessive thrust generated by the pneumatic rotary spraying machine.

To avoid at least some of these difficulties, the pump was operated at a very low pressure (less than 30 % of normal pressure required for Guniting or Shotcreting). Pumping was continued until all the wall cavities were filled and the wall were inspected the next day for evidence of core/skin bondability.

The results of this test were quite surprising.

The NFC mixes exhibit the flow behaviour of loose fill, whilst being pumpable similar to wet concrete mixes.

The pneumatic rotary spraying machine, which was designed primarily for spraying dry concrete mixes, was able to pump the wet NFC mixes with water/cement ratios of around 0.5 by weight, and containing 10 mm and 20 mm maximum aggregate size without any line blockage or jamming.

The sandwich walls were successfully filled with NFC mixes. Complete void-free filing of cavities was achieved. The NFC mixes appeared to flow, consolidate and fill all wall cavities without bridging or clumping.

The staple-fixed walls were able to withstand the dynamic thrust generated due to core filling without blowing out. Especially surprising was wall # 7 in Table 6 above which incorporated a 4.5 mm thick fibre cement sheet. This thickness is outside the

normal range conventionally used for permanent form work in concrete filled cavities. Such a thin sheet would normally be expected to blow out or bow considerably.

Filling from a six metre height in one lift was carried out successfully without excessive bowing, sheet blow out or presence of unfilled core areas (see wall #8 in Table 6 above). This is very surprising since this test was expected to exhibit some unfilled areas near the bottom of the wall due to the height of the drop.

Wall cavities with 600 mm c/c stud spacing were successfully filled without excessive bowing or sheet blow out (see wall # 5 in Table 6 above). This was entirely unexpected since such a large span between studs, ie 600 mm would normally cause excessive bowing or sheet blow out.

The sandwich walls (including the staple-fixed walls) were successfully completely filled with the NFC mixes. The NFC mixes appeared to flow, consolidate and fill all the wall cavities without bridging or clumping.

Consistent bondability was achieved between the NFC core infill and the FRC skins thus enabling the sandwich walls to exhibit solid masonry feel.

The resultant core-filled walls exhibited very good surface flatness with bowing between the studs in the core-filled walls of less than 1 mm.

As a result, it was clear that the low or no fines concrete mix arising from the present invention provided an excellent pumpable mix. The use of the pneumatic rotary dry mix spraying machine for pumping such a low or no fines concrete mix was also quite surprising. In particular, the combination of the cement additive along with the reduction in normal pressure provide a significant advance in techniques and machinery for filling cavity walls.

Accordingly, it can be seen that the present invention provides a viable alternative to conventional masonry systems and current lightweight wall systems. It will further be appreciated that the disclosed panel construction may be altered or embodied in other forms without departing from the spirit or scope of the present invention.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A lightweight concrete mix comprising 1 part by volume of a cementitious binder, 2-10 parts inert coarse aggregate, a cement additive in an amount of between 0.05-0.3% by weight of the cementitious binder and an effective amount of water,

the additive including 40-99% of a viscosity enhancing agent which in water either dissolves or forms colloidal dispersions, and 1-60% of an air entrainment agent/surfactant adapted to entrain air when mixed with water and/or pumped.

2. A lightweight concrete mix as claimed in claim 1, wherein the additive comprises 60-90% of a viscosity enhancing agent.

3. A lightweight concrete mix as claimed in claim 1 or 2, wherein the additive comprises 70-85% of a viscosity enhancing agent.

4. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the additive comprises 10-50% of air entrainment agent/surfactant.

5. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the additive comprises 20-40% of air entrainment agent/surfactant.

6. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the viscosity enhancing agent comprises one or more thixotropic agents which either dissolve in water or form colloidal dispersions in the presence of water to produce an increase in the viscosity of the water.

7. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the viscosity enhancing agent is selected from the group consisting of cellulose derivatives, polysaccharide or synthetic hydrophilic polymers.

8. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the viscosity enhancing agent is selected from the group consisting of hydroxymethylcellulose, hydroxyethylcellulose and hydroxypropylmethylcellulose.

9. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the viscosity enhancing agent is selected from the group consistent of starches or alginate.

10. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the viscosity enhancing agent is a synthetic hydrophilic polymer or copolymer selected from the group consisting of polyvinyl alcohols, polyethylene or polypropylene oxides.

11. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the air entraining agent comprises one or more nonionic, cationic or anionic surfactants.

12. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the air entrainment agent is selected from the group consisting of sodium salts of alpha olefin sulphonates, sodium lauryl sulphate or sulphonate.

13. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the cementitious binder is an inorganic material comprising calcium, aluminium, silicone, oxygen or sulphur compounds with sufficient hydraulic activity to solidify or harden in the presence of water.

14. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the cementitious compound is selected from the group consisting of common portland cements, fast setting or extra fast setting cements, sulphate resisting cements, modified cements, alumina cements, high alumina cements, calcium aluminate cements and cements containing secondary compounds such as fly ash, pozzolana and the like.

15. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the coarse aggregate has a size range of between 5 and 20 mm with 5% maximum aggregate coarser than 20 mm and 10% maximum finer than 5 mm size.

16. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the coarse aggregate is gap graded as a single size with the highest proportion being between 10 mm and 20 mm.

17. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the coarse aggregate contains between 0 and 10% by weight of fines.

18. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the coarse aggregate is inert with respect to the other components of the mixture and is selected from the group consisting of washed river gravel, crushed igneous rock or limestone, lightweight aggregate, pumice, scoria, expanded shale (foamed clay) or other artificial aggregates such as crushed hard-burnt clay bricks or air-cooled blast furnace slag.

19. A lightweight concrete mix as claimed in any one of the preceding claims, wherein for load bearing purposes, the mix may contain 0 to 40% of a thickener, high reactive pozzalanes such as silica fumes, water sealing agents, water reducing agents, setting rate modifiers, hardeners, plasticisers or water-proofing agents.

20. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the water to cement ratio is 0.3 to 0.8.

21. A lightweight concrete mix as claimed in any one of the preceding claims, wherein the water to cement ratio is 0.4 to 0.7.

22. A method of constructing a panel comprising erecting a substantially rigid frame, attaching to the frame front and rear fibre reinforced cementitious sheets to form a cavity there between and providing to the cavity a lightweight concrete loose fill comprising one part by volume of a cementitious binder, 2-10 parts inert coarse aggregate, a cement additive in an amount of between 0.05-0.3% by weight of the cementitious binder and an effective amount of water,

the additive including 40-99% of a viscosity enhancing agent which in water either dissolves or forms colloidal dispersions, and 1-60% of an air entrainment agent/surfactant adapted to entrain air when mixed with water and/or pumped.

23. A method as claimed in claim 22, wherein the entire cavity is filled with the lightweight concrete loose fill.

24. A method as claimed in claim 22 and 23, wherein the cavity is partially filled with the lightweight concrete loose fill, the remainder being left dry or filled with another material.

25. A method as claimed in claim 24, wherein the additive comprises 60-90% of a viscosity enhancing agent.

26. A method as claimed in claim 24 or 25, wherein the additive comprises 70-85% of a viscosity enhancing agent.

27. A method as claimed in any one of claims 24 or 26, wherein the additive comprises 10-50% of air entrainment agent/surfactant.

28. A method as claimed in any one of claims 24 to 27, wherein the additive comprises 20-40% of air entrainment agent/surfactant.

29. A method as claimed in any one of claims 24 to 28, wherein the viscosity enhancing agent comprises one or more thixotropic agents which either dissolve in water or form colloidal dispersions in the presence of water to produce an increase in the viscosity of the water.

30. A method as claimed in any one of claims 24 to 29, wherein the viscosity enhancing agent is selected from the group consisting of cellulose derivatives, polysaccharide or synthetic hydrophilic polymers.

31. A method as claimed in any one of claims 24 to 30, wherein the viscosity enhancing agent is selected from the group consisting of hydroxymethylcellulose, hydroxyethylcellulose and hydroxypropylmethylcellulose.

32. A method as claimed in any one of claims 24 to 31, wherein the viscosity enhancing agent is selected from the group consistent of starches or alginate.

33. A method as claimed in any one of claims 24 to 32, wherein the viscosity enhancing agent is a synthetic hydrophilic polymer or copolymer selected from the group consisting of polyvinyl alcohols, polyethylene or polypropylene oxides.

34. A method as claimed in any one of claims 24 to 33, wherein the air entraining agent comprises one or more nonionic, cationic or anionic surfactants.

35. A method as claimed in any one of claims 24 to 34, wherein the air entrainment agent is selected from the group consisting of sodium salts of alpha olefin sulphonates, sodium lauryl sulphate or sulphonate.

36. A method as claimed in any one of claims 24 to 35, wherein the cementitious binder is an inorganic material comprising calcium, aluminium, silicone, oxygen or sulphur compounds with sufficient hydraulic activity to solidify or harden in the presence of water.

37. A method as claimed in any one of claims 24 to 36, wherein the cementitious compound is selected from the group consisting of common portland cements, fast setting or extra fast setting cements, sulphate resisting cements, modified cements, alumina cements, high alumina cements, calcium aluminate cements and cements containing secondary compounds such as fly ash, pozzalana and the like.

38. A method as claimed in any one of claims 24 to 37, wherein the coarse aggregate has a size range of between 5 and 20 mm with 5% maximum aggregate coarser than 20 mm and 10% maximum finer than 5 mm size.

39. A method as claimed in any one of claims 24 to 38, wherein the coarse aggregate is gap graded as a single size with the highest proportion being between 10 mm and 20 mm.

40. A method as claimed in any one of claims 24 to 39, wherein the coarse aggregate contains between 0 and 10% by weight of fines.

41. A method as claimed in any one of claims 24 to 40, wherein the coarse aggregate is inert with respect to the other components of the mixture and is selected from the group consisting of washed river gravel, crushed igneous rock or limestone, lightweight aggregate, pumice, scoria, expanded shale (foamed clay) or other artificial aggregates such as crushed hard-burnt clay bricks or air-cooled blast furnace slag.

42. A method as claimed in any one of claims 24 to 41, wherein for load bearing purposes, the mix may contain 0 to 40% of a thickener, high reactive pozzalanes such as silica fumes, water sealing agents, water reducing agents, setting rate modifiers, hardeners, plasticisers or water-proofing agents.

43. A method as claimed in any one of claims 24 to 42, wherein the water to cement ratio is 0.3 to 0.8.

44. A method as claimed in any one of claims 24 to 43, wherein the water to cement ratio is 0.4 to 0.7.

45. A building panel comprising a substantially rigid frame defining front and rear faces, front and rear fibre reinforced cementitious sheets attached to the frame to form a cavity there between, the cavity being at least partially filled with a lightweight concrete loose fill,

wherein the lightweight loose fill comprises 1 part by volume of cementitious binder, 2-10 parts inert coarse aggregate, a cement additive in an amount between 0.05-0.3% by weight of the cementitious binder and an effective amount of water,

the additive including 40-99% of a viscosity enhancing agent which in water either dissolves or forms colloidal dispersions and 1-60% of an air entrainment agent/surfactant adapted to entrain air when mixed with water and/or pumped.

46. A building panel as claimed in claim 45, wherein the entire cavity is filled with the lightweight concrete loose fill.

47. A building panel as claimed in claim 45 and 46, wherein the cavity is partially filled with the lightweight concrete loose fill, the remainder being left dry or filled with another material.

48. A building panel as claimed in any one of claims 45 to 47, wherein that portion of the cavity filled with a lightweight concrete loose fill has, on curing, between 20-40% by volume of interconnected pores/voids.

49. A building panel as claimed in claim 48, wherein the additive comprises 60-90% of a viscosity enhancing agent.

50. A building panel as claimed in claim 48 or 49, wherein the additive comprises 70-85% of a viscosity enhancing agent.

51. A building panel as claimed in any one of claims 48 to 50, wherein the additive comprises 10-50% of air entrainment agent/surfactant.

52. A building panel as claimed in any one of claims 48 to 51, wherein the additive comprises 20-40% of air entrainment agent/surfactant.

53. A building panel as claimed in any one of claims 48 to 52, wherein the viscosity enhancing agent comprises one or more thixotropic agents which either dissolve in water or form colloidal dispersions in the presence of water to produce an increase in the viscosity of the water.

54. A building panel as claimed in any one of claims 48 to 53, wherein the viscosity enhancing agent is selected from the group consisting of cellulose derivatives, polysaccharide or synthetic hydrophilic polymers.

55. A building panel as claimed in any one of claims 48 to 54, wherein the viscosity enhancing agent is selected from the group consisting of hydroxymethylcellulose, hydroxyethylcellulose and hydroxypropylmethylcellulose.

56. A building panel as claimed in any one of claims 48 to 55, wherein the viscosity enhancing agent is selected from the group consistent of starches or alginate.

57. A building panel as claimed in any one of claims 48 to 56, wherein the viscosity enhancing agent is a synthetic hydrophilic polymer or copolymer selected from the group consisting of polyvinyl alcohols, polyethylene or polypropylene oxides.

58. A building panel as claimed in any one of claims 48 to 57, wherein the air entraining agent comprises one or more nonionic, cationic or anionic surfactants.

59. A building panel as claimed in any one of claims 48 to 58, wherein the air entrainment agent is selected from the group consisting of sodium salts of alpha olefin sulphonates, sodium lauryl sulphate or sulphonate.

60. A building panel as claimed in any one of claims 48 to 59, wherein the cementitious binder is an inorganic material comprising calcium, aluminium, silicone, oxygen or sulphur compounds with sufficient hydraulic activity to solidify or harden in the presence of water.

61. A building panel as claimed in any one of claims 48 to 60, wherein the cementitious compound is selected from the group consisting of common portland cements, fast setting or extra fast setting cements, sulphate resisting cements, modified cements, alumina cements, high alumina cements, calcium aluminate cements and cements containing secondary compounds such as fly ash, pozzalana and the like.

62. A building panel as claimed in any one of claims 48 to 61, wherein the coarse aggregate has a size range of between 5 and 20 mm with 5% maximum aggregate coarser than 20 mm and 10% maximum finer than 5 mm size.

63. A building panel as claimed in any one of claims 48 to 62, wherein the coarse aggregate is gap graded as a single size with the highest proportion being between 10 mm and 20 mm.

64. A building panel as claimed in any one of claims 48 to 63, wherein the coarse aggregate contains between 0 and 10% by weight of fines.

65. A building panel as claimed in any one of claims 48 to 64, wherein the coarse aggregate is inert with respect to the other components of the mixture and is selected from the group consisting of washed river gravel, crushed igneous rock or limestone, lightweight aggregate, pumice, scoria, expanded shale (foamed clay) or other artificial aggregates such as crushed hard-burnt clay bricks or air-cooled blast furnace slag.

66. A building panel as claimed in any one of claims 48 to 65, wherein for load bearing purposes, the mix may contain 0 to 40% of a thickener, high reactive pozzalanes such as silica fumes, water sealing agents, water reducing agents, setting rate modifiers, hardeners, plasticisers or water-proofing agents.

67. A building panel as claimed in any one of claims 48 to 66, wherein the water to cement ratio is 0.3 to 0.8.

68. A building panel as claimed in any one of claims 48 to 67, wherein the water to cement ratio is 0.4 to 0.7.

69. A lightweight concrete mix, substantially as herein described with reference to any one of the embodiments of the invention illustrated in the accompanying drawings and/or examples.

70. A method of constructing a panel, substantially as herein described with reference to any one of the embodiments of the invention illustrated in the accompanying drawings and/or examples.

71. A building panel, substantially as herein described with reference to any one of the embodiments of the invention illustrated in the accompanying drawings and/or examples.

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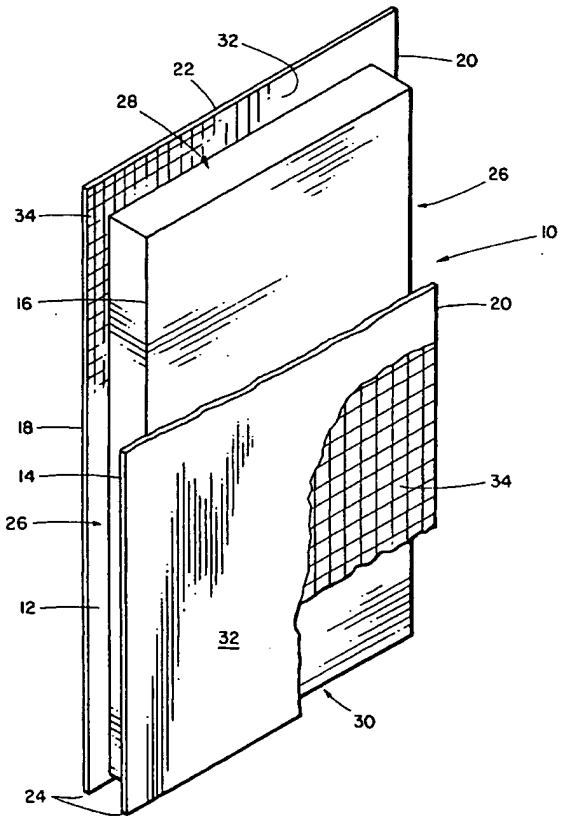
(54) Title: SANDWICH WALL CONSTRUCTION AND DWELLING



(57) Abstract: A construction wall system having, rigid inner and outer rectangular panels on either side and end edges on ends. The panels spaced apart from one another, with parallel junction strips between the inner and outer panels, with end junction strips secured between the panels. End junction strips define junction channels along the side edges between the panels, with inwardly spaced spacer strips secured between the inner and outer panels relative to the end edges of the panels to define end junction channels between the inner and outer panels. Panels and strips all being formed of polymer-modified fibre reinforced concrete material, with synthetic plastic foam material filling the spaces between the inner and outer panels.

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SANDWICH WALL CONSTRUCTION AND DWELLING

TECHNICAL FIELD

The invention relates to a sandwich-type wall structure and to a wall construction using a plurality of sandwich wall structures, and to a dwelling constructed from such sandwich wall structures.

BACKGROUND ART

Conventional construction of walls involves the erection of framing and the exterior is then covered in with some form of sheathing, drywall, stucco and/or bricks or siding. Insulation is placed between the framing or studs, and the interior wall is then covered in usually with plaster board of some kind. This involves a large number of different operations, using on site labour, which is paid at relatively high hourly rates. Materials were often subject to damage by insects, and by rot.

Clearly it is desirable to provide for a low cost construction technique in which portions of a building may be pre-built and finished in a factory, and which use durable, long lasting materials not subject to attack by rot, weather or insects. It is further clearly desirable that such building components shall be capable of being manufactured by relatively unskilled factory labour, and may be erected to form a low cost dwelling or other building, in a speedy, efficient manner, using a minimum of on-site labour with minimum skills, and requiring only a minimum of heavy equipment. The buildings using this system will preferably be capable of withstanding hurricane winds and earthquake shocks.

A partial solution is to use wall panel systems, in which wall panels can be prefabricated to standard sizes. The panels are then simply put together to erect the completed walls. These systems however suffer from a variety of disadvantages such as the use of various different materials, having differential rates of expansion and contraction, and the use of some materials which may

be subject to deterioration, rot, or attack by insects and the like.

In co-pending U.S. Application 09/024,656, Title: Composite Wall Construction and Dwelling therefrom, and assigned to the assignee of this application, there is described a wall structure and dwelling meeting many of these objectives.

It is found however, that a sandwich like wall structure, which is somewhat less costly, but retains many useful qualities comparable to the earlier wall structure, can be made without significant loss of strength. In particular, in the system described in the aforesaid application, the system provided for the use of front and rear spaced apart panels, and partition walls extending between the front and rear panels of the wall structure, defining interior cavities and further called for the use of expanded polyurethane foam insulation material in the cavities. While this was relatively expensive, the walls resulting from such wall structures were strong and well-insulated and were otherwise satisfactory. It has been found that in practice significant economies can be made in cost, without any significant loss of properties, and at the same time production both at the factory, where the wall structures are produced, and also in the erection of such wall structures, can be substantially speeded up.

DISCLOSURE OF THE INVENTION

With a view to achieving the foregoing advantages the invention provides a sandwich wall structure comprising, an inner rigid panel and an outer rigid panel of rectangular shape formed of polymer-modified fibre reinforced concrete material and defining length and breadth dimensions and defining side edges on either side and upper and lower end edges on ends thereof said panels being spaced apart from one another, an insulation block formed of rigid expanded polystyrene thermal insulation material bonded between said inner and outer panels, the block defining upper and lower and end surfaces all such surfaces being spaced inwardly relative to the side and end edges of said panels whereby to define side and upper end junction channels, and lower

registering channels, between said inner and outer panels.

The invention further comprises a wall construction having a plurality of such sandwich wall structures, and concrete filling in said side channels and said upper end junction channels between adjacent sides and extending between adjacent upper ends of said panels, said concrete extending integrally from one said junction channel into the adjacent junction channel of two adjacent wall structures.

The invention further comprises a rectangular composite wall which comprises a plurality of such sandwich wall structures erected side by side, and defining continuous horizontal junction channels at the upper ends of said wall structures, and including concrete filling said continuous horizontal junction channels and further concrete filling vertical junction channels between adjacent sides of adjacent panels.

The invention further comprises a wall construction as described and including a shallow locating channel formed along the lower edge of each said sandwich wall structures and including registering strip means secured to a construction footing, adapted to fit within said shallow registering channel, whereby to register said sandwich wall structures, and secure their lower edges against movement. Preferably there will also be a matching reinforcing strip within the interior of the locating channel secured along the downwardly directed surface of the insulation block, for contacting the registering strip means.

Reinforcing bars of steel may typically be incorporated in the vertical and upper horizontal junction channels and embedded in the concrete.

The invention further comprises a corner construction consisting of interlocking panels, formed at adjacent ends of adjacent sandwich wall structures with a shorter end edge and a longer end edge, and wherein, when said shorter and longer end edges are placed adjacent one another, they enclose a generally rectangular enclosure and metallic L-shaped angles secured to adjacent end edges of said inner and outer panels, and securing adjacent inner and adjacent outer panels together and concrete received in said generally rectangular enclosures thereby bonding said wall structures together

at said corner. Preferably the rectangular enclosures will be of truncated L-shape in section.

The invention further comprises a dwelling or other housing structure having walls and a roof and said walls being formed of a plurality of sandwich wall structures each said wall structure comprising, inner and outer rigid panels of polymer-modified fibre reinforced concrete material and an insulation block formed of rigid expanded polystyrene between said panels and means bonding said panels to said insulation block with their planes parallel, junction channels formed along the sides and upper ends of each said wall structure, and, concrete filling in said junction channels between adjacent sides and extending between adjacent ends of said sandwich wall structures said concrete extending integrally from one said junction channel into the adjacent junction channel of an adjacent wall structure.

The roof preferably comprises a plurality of roof structures each consisting of upper and lower rigid panels of polymer modified concrete material, and a block of expanded polystyrene thermal insulation material bonded therebetween and steel reinforcing channels located between said upper and lower panels and bonded thereto, said upper and lower panels and said reinforcing channels defining open spaces therebetween, and connection means extending upwardly from said walls through said roof, and being secured in said roof panels.

The roof panels may be joined by stepped ledge formations in a form of "ship-lath" connection.

The invention further comprises the provision of a dwelling or other housing structure having both walls and the roof as described above, and further having an intermediate floor structure composed of floor structure panels substantially as described in connection with the roof structure panels.

The invention further comprises that said connection means are in the form of generally cone shaped openings formed in said roof panels, and being located and adapted to receive reinforcing bars extending upwardly from said walls, and concrete material filling said cone shaped recesses and bonding around said reinforcing bars and securing said roof in position.

Preferably the roof will be comprised of a plurality of relatively narrow roof panels, each of the roof panels having male channel formations and interlocking female channel formations at their respective side edges, whereby said roof panels may be mated together with said male and female channel formations interengaged, to form a roof spanning the space of a building.

The invention further comprises a method of constructing a wall panel structure having the foregoing advantages, and a method of constructing walls, and a dwelling using the wall structures according to the foregoing.

The various features of novelty which characterize the invention are pointed out with more particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be made to the accompanying drawings and descriptive matter in which there are illustrated and described preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective illustration partially cut away of a sandwich wall structure illustrating one form of the invention;

Figure 2 is a section along the line 2-2 of Figure 1;

Figure 3 is a section along the line 3-3 of Figure 1;

Figure 4 is a side elevational view partially cut away showing two composite wall structures erected on a concrete foundation, and showing them assembled together using poured concrete as the joining medium;

Figure 5 is a section along the line 5-5 of Figure 1 greatly enlarged to show the method of securing the portions of the composite wall structure together;

Figure 6 is a section along the line 6-6 of Figure 4;

Figure 7 is a section along the line 7-7 of Figure 4;

Figure 8 is a schematic side elevational view of a simple dwelling illustrating the use of the invention in construction;

Figure 9 is a top plan view of the building plan of the dwelling of Figure 8;

Figure 10 is a section along the line 9-9 of Figure 9, showing joining two side walls at a right angular corner;

Figure 11 is a section along the line 9-9 of Figure 9 greatly enlarged showing joining side walls and a partition wall together at a Tee junction;

Figure 12 is a section of a junction of four walls;

Figure 13 is a sectional illustration illustrating the attachment of a floor panel between two upright walls;

Figure 14 is a section illustrating the construction of a plurality of roof panels placed edge to edge in interlocking mating relation;

Figure 15 is a section through the end edge of a typical roof or floor panel;

Figure 16 is an exploded cut away view of another form of roof panel connection;

Figure 17 is section along the line 16-16 of Figure 8, illustrating the attachment of a roof panel to a side wall, and,

Figure 18 is a section showing the junction of two roof panels at a ridge, where two portions of the roof meet one another, typically along the axis of an interior partition wall.

MODES OF CARRYING OUT THE INVENTION

As already indicated the invention relates generally to a modular sandwich-type wall structure, which is modular in nature and which is factory built. The modular wall structures can be transported in large numbers to a building site and then can be erected basically by hand labour, and using simple poured concrete facilities.

The basic wall structure is illustrated in Figures 1 through 3. It will be seen to comprise a modular sandwich wall structure illustrated generally as 10 . The wall structure 10 has an outer panel 12 and an inner panel 14 . They are both of rectangular shape and of the same size, and typically may be in the

region of four feet by eight feet, or more depending upon the height of the dwelling, or other building to be erected.

Panels 12 and 14 are spaced apart from one another, and, between the panels 12 and 14, there is secured and a block of insulation material 16 . The block of insulation material 16 is of rectangular shape being in the form of a flattened solid body, defining side edge walls 18 and 20, and top and bottom edge walls 22 and 24.

The block of insulation material 16 is formed of thermoplastic material, typically being expanded polystyrene bead material, of a type well known in the art, and requiring no special description or formulation.

The panels 12 and 14 are bonded together on opposite sides of the block 16 by any suitable adhesive means. The side edge and top and bottom edge dimensions of the block 16 are somewhat reduced in relation to the dimensions of the side edges and the top edges of the panels 12 and 14.

In this way, it will be seen that along either side of the sandwich wall structure, there are defined a generally open sided rectangular vertical channels 26, and along the top edge a horizontal channel 28. Along the lower edge of the wall structure there is defined a shallow lower rectangular channel 30 which it will be seen, is of reduced depth dimension in relation to the channels 26 and 28.

Each of the panels 12 and 14 are of identical construction. They will be seen to comprise sheets 32 of polymer-reinforced concrete material, typically having a thickness of about one half to three quarters of an inch. On at least one side of the polymer-reinforced concrete material, there are located fibre reinforced matting sheets 34. Such sheets of polymer-reinforced concrete, reinforced with fibre matting, typically resin fibre matting, form a structure of great strength and bending resistance and load carrying capacity.

The insulation block 16 is bonded to the interior of the inner and outer panels 12 and 14 by any suitable adhesive means. This will bond securely to the inner surfaces of the panels 12 and 14, defined by the fibre resin mesh reinforcement 34, thereby bonding the panels 12 and 14 together with the block 16 to make a homogenous integral solid sandwich wall structure.

All of these functions can be carried out in the factory with great precision, and also with a minimum of instruction. The wall structures 10 being largely formed of lightweight material are relatively light, and can be handled by manual labour without the use special mechanical lifting devices.

Referring now to Figures 4, 5, 6 and 7, the wall structures 10 can be associated together to form a wall shown generally as 40 in Figure 4. The wall 40 illustrated in Figure 4 is merely illustrative of the way in which the wall structures 10 can be used to be construct and erect a wall. Typically the wall of a single storey building or dwelling, will be defined by the height, i.e. the length dimension of each panel 10. As shown in Figure 4, the panels 10 are erected on a concrete base or slab or foundation indicated as F . In order to locate the wall structures 10 a locating strip 42 is secured on the surface of the slab F by nails or other fastenings. The locating strip 42 in this embodiment is typically formed by a metal channel but may also be a strip of the polymer-reinforced concrete panel material. It fits within the channels 30 between the front and rear panels 12 and 14.

The lower channel 30 (Figure 2) is arranged so that it has a sufficient height to fit over the locating strip 42, and make a snug fit thereon.

In order to join two adjacent wall structures 10 together, in edge to edge abutting relation, concrete material M is poured down through the channels 26 and 26, between two adjacent structures 10. Additional bracing is usually temporarily required adjacent the joints between the panels 12 and 14 of the adjacent wall structures 10, and this of course may be provided in any suitable manner. For example metal bracing channels 44 secured by wire clips 46 may be used. Such temporary bracing may be required in order to prevent the pressure of the concrete from distorting the edges of the panels 12 and 14 where they define the channels 26. However, the bracing can usually be removed after twenty-four hours as the concrete material M cures.

Usually, there will be a plurality of vertical reinforcing rods R placed in the channels 26 prior to pouring of the concrete, in accordance with well known construction techniques.

In order to provide a horizontal top beam, for supporting the roof

concrete M is also poured in the horizontal channels 28 along the top of the wall structures 10. Generally speaking, since the depth of this concrete is only a few inches, there will be no additional bracing required at this point.

Such concrete M will usually be reinforced with suitable reinforcing rods. When the wall is finished, the individual wall structures 10 are joined edge to edge in abutting relation, and the wall is supported by vertical columns of cured concrete M, and by horizontal beams of concrete M, which are all poured integrally at the same time and form a structure of great strength. Additional rebars may be placed at intervals extending upwards for attachment of a roof.

It will now be apparent from the foregoing description that the sandwich wall structures 10 can be assembled together to provide walls for a dwelling or other building. Referring now to Figures 8 and 9, such a building is illustrated generally as 50. Figure 8 is a schematic side elevation of such a building, typically a small, low cost dwelling, and Figure 9 is a floor plan of such a building.

It will be seen that the building 50 is provided with four exterior walls 52, and a central partition wall 54, extending between two of the side exterior walls 52. All of the walls 52 and 54 are made of sandwich wall structures 10 as described in Figures 1 through 3, and all of the wall structures are joined by means of poured concrete columns. In Figure 9 the poured concrete columns are indicated as C. The junction between the exterior side walls and the partition walls is achieved by means of a generally Tee-shaped poured corner containing concrete column C, illustrated in more detail in Figure 11. Portions of the inner panels 14 of two abutting wall panels may be cut away as shown to allow concrete to flow into the Tee junction.

The corners of the walls 52 in this embodiment require modified wall structures shown in Figure 10.

These modified wall structures are formed with outer panels 12A which are extended somewhat along one edge as at 56, and have modified interior panels 14A , which are cut somewhat shorter as at 58.

Two wall structures 10-10 as shown, may be formed into a corner by placing the longer and shorter edges 12A and 14A in edge abutting relation as

shown in Figure 10. This forms a right angular corner. Reinforcing corner angles 60 are secured whereas the interior at the junctions of the outer panels 12A and remain in place. Suitable reinforcing rods are placed down the L-shaped space defined by the longer and shorter portions 56 and 58, and concrete is poured down in the space. The rebars are interlocked by straps as needed. The concrete will form a generally L-shaped column, extending around the corner, and holding both wall structures securely together and holding them upright.

At this point, reviewing the simple dwelling structure of Figures 8 and 9 it will be seen that the four walls and the central partition wall are all constructed of the sandwich wall structures 10 as illustrated generally in Figure 1, and that they are joined edge to edge to form the complete walls by means of poured concrete columns. The entire structure thus has great integral strength, and at the same time has great resistance to thermal transmission. Being provided with a plurality of vertical supporting concrete columns, reinforced as described, the structure will have great resistance to earthquake and other shocks. At the same time it is apparent that it can readily be erected, by manual labour simply taking the sandwich wall structures 10 illustrated in Figure 1 and erecting them side by side and corner to corner, supporting them vertically, and pouring concrete using relatively primitive equipment such as will be readily available even in remote locations.

A floor can be constructed, in multi-storey dwelling, (not illustrated), by taking somewhat modified sandwich structures 70, and attaching them between lower and upper walls 72 and 74.

In this case, from the near upper channel 26 of the lower wall 72, a connecting rebar 76 extends upwardly.

The panel 70 is formed with a generally frusto-conical opening or recess 78. The rebar 76 fits within the recess, and concrete is then poured down into the recess and bonds the rebar thereby holding the floor in position.

The upper wall 74 is attached once again in the manner shown in connection with Figures 4 and 5.

Reference may now be made to the roof 80 of the dwelling.

The roof is best illustrated in Figures 14, 15, 16, 17 and 18. It will be made up of a plurality of elongated relatively narrow roof sandwich members 82. The roof members 82 comprise upper and lower panels 84 and 86 formed of polymer modified concrete, sandwiched around a polystyrene panel of indulation 87.

A plurality of steel C channels 88 are bonded between the interior surfaces of the panels. The panels 84 and 86 are otherwise formed in the same way, with reinforcing fibre glass mesh, as described in connection with the panels of Figure 1.

Along one side edge of each of the sandwich members 80, (Fig 14) a metal C section 90 is recessed inwardly between the panels 82 and 84 so as to leave a shallow channel. Along the other side edge of the member 80, a C section 92 is secured flush with the ends of the roof members 80. A mating strip member 94 is bonded to the exterior of the C section 92 , and is dimensioned so as to make a snug fit between the space defined within C channel 90 along the other side edge.

In this way the roof members 82 can be set side by side together with a form of tongue and groove interconnection between them.

Fig 15 illustrates and alternate form of interconnection. In this case two roof panels have identical edge portions formed by inwardly faced C channels 96.

The surfaces of the C channels can be bonded together by adhesive.

Fig 16 illustrates a further form of roof panel junction.

In this case modified C channels 98 are used. These channels are formed with offset portions 100. They are turned to face upwardly along one edge and downwardly along the opposite edge of each panel.. When the panels are placed edge to edge, the channels 98 will interfit and form a type of "ship lath" joint, having great strength and being weather proof. For added security a screw 102 can be inserted at spaced intervals along each joint.

In order to secure the roof panels to the walls vertically extending rebars 104 are located and dimensioned so as to interfit with generally conically shaped recesses 106 , formed at each end of each of the roof members or

panels (Figs 17 and 18).

With this arrangement, concrete is then filled in around the conical recess thereby bonding to the rebars and holding the roof firmly in position.

Similar arrangements can be made for the pitched roof shown in Figure 10, the details of which require no special description.

It will also be understood that, in a two storey structure, the floor members can be provided to serve as the floor of the second storey (Fig 13).

The floor structures will be somewhat similar to the roof structures described above, but will usually be somewhat thicker, ie. in the region of seven inches overall, with a half inch panel top and bottom, and a six inch core of insulation block.

The floor structures will be reinforced along with side edges by metal reinforcing channels, and also similar reinforcing channels along their end edges.

Along one side edge, the channel will be turned outwardly so that it defines a U-shaped recess. Along the other edge the channel will be turned inwardly and simply fits over the insulation block. Alternatively the "ship lath" type of joint can be used as in the roof (Fig 16).

Along the exterior of the wall a rectangular strip of polymer reinforced concrete material.

The foregoing is a description of a preferred embodiment of the invention which is given here by way of example only. The invention is not to be taken as limited to any of the specific features as described, but comprehends all such variations thereof as come within the scope of the appended claims.

CLAIMS:

1. A construction wall system comprising;

an inner rigid panel and an outer rigid panel of rectangular shape and defining length and breadth dimensions and defining side edges on either side and end edges on ends thereof said panels being spaced apart from one another;

a plurality of intermediate junction strips having a predetermined width secured between said inner and outer panels, and said junction strips having a length less than the length of said panels, and being arranged in parallel spaced apart relation, at spaced intervals between said inner and outer panels;

a plurality of end junction strips having a predetermined width equal to said intermediate junction strips secured between said inner and outer panels adjacent opposite side edges thereof, and spaced inwardly from said side edges whereby to define junction channels along said side edges between said inner and outer panels, a plurality of spacer strips having a predetermined width equal to the width of said junction strips and secured between said inner and outer panels transverse to said junction strips and adjacent thereto, said spacer strips being spaced inwardly relative to said end edges of said panels whereby to define end junction channels between said inner and outer panels, said panels and said strips all being formed of polymer-modified fibre reinforced concrete material.

2. A wall system as claimed in Claim 1, and including a synthetic plastic foam material filling the spaces between said side walls and said end walls and said intermediate junction strips.

3. A wall system as claimed in Claim 2 and including a plurality of foam filling openings in one of said end walls, and foam filled into the spaces

defined between the intermediate channels after the wall system has been assembled.

4. A wall system as claimed in Claim 3 and including a plurality of such wall systems erected side by side, and defining a continuous open junction channel at the upper ends of said wall construction, and including concrete filling said continuous open topped junction channel.

5. A wall system as claimed in Claim 3 and including a shallow locating channel formed along the lower edge of each said wall system, and including registering strip means secured to a construction footing, adapted to fit within said shallow registering channel, whereby to register all of said wall systems, and secure their lower ends against movement.

6. A wall construction having a plurality of such wall structures and each said wall structure comprising, inner and outer rigid panels of polymer-modified fibre reinforced concrete material, and means bonding said panels together in spaced apart relation with their planes parallel, junction channels formed along the sides and ends of said wall structure, and, concrete filling in said junction channels between adjacent sides and adjacent ends of said structure said concrete extending integrally from one said junction channel into the adjacent junction channel of two adjacent wall structures.

7. A wall construction as claimed in Claim 6 and wherein same said wall panels are formed at adjacent ends with a shorter end edge and a longer end edge, and wherein, when said shorter and longer end edges are placed adjacent one another, they enclose a rectangular enclosure, and concrete received in said rectangular enclosures thereby bonding said wall panels together to form a corner.

8. A dwelling or other housing structure having walls and a transverse

covering and a plurality of wall structures all being composed of composite wall structures and each said wall structure comprising;

inner and outer rigid panels of polymer-modified fibre reinforced concrete material and means bonding said panels together in spaced apart relation with their planes parallel;

junction channels formed along the sides and ends of said wall structure; and,

concrete filling in said junction channels between adjacent side and adjacent ends of said structure said concrete extending integrally from one said junction channel into the adjacent junction channel of two adjacent wall structures.

9. A dwelling structure as claimed in Claim 8 and including a plurality of transverse panels, each consisting of upper and lower rigid panels of polymer modified concrete material, and steel reinforcing channels located between said upper and lower panels and bonded thereto, said upper and lower panels and said reinforcing channels defining open spaces therebetween, and foam plastic material filling said open spaces, and connection means extending upwardly from said walls through said transverse structure, and being secured in said transverse structure panels.

10. A dwelling structure as claimed in Claim 9 wherein said connection means are in the form of generally cone shaped openings formed in said transverse panels, and being located and adapted to receive reinforcing bars extending upwardly from said walls, and concrete material filling said cone shaped recesses and bonding around said reinforcing bars and securing said transverse structure in position.

11. A dwelling structure as claimed in Claim 10 and including a plurality of relatively narrow transverse panels, each of the transverse panels having interlocking male and female formations at their respective side edges,

whereby said roof panels may be mated together, to form a transverse structure spanning the space of a building.

12. A dwelling structure as claimed in Claim 11 wherein said transverse panels form a floor for a second storey of said dwelling structure.

13. A method of constructing a wall panel structure having an inner rigid panel and an outer rigid panel of rectangular shape and defining length and breadth dimensions and defining side edges on either side and end edges on ends thereof said panels being spaced apart from one another and , a plurality of intermediate junction strips having a predetermined width secured between said inner and outer panels, and said junction strips having a length less than the length of said panels, and being arranged in parallel spaced apart relation, at spaced intervals between said inner and outer panels and, a plurality of end junction strips having a predetermined width equal to said intermediate junction strips secured between said inner and outer panels adjacent opposite side edges thereof, and spaced inwardly from said side edges whereby to define junction channels along said side edges between said inner and outer panels, a plurality of spacer strips having a predetermined width equal to the width of said junction strips and secured between said inner and outer panels transverse to said junction strips and adjacent thereto, and comprising the steps of;

securing said spacer strips and said intermediate junction strips between said inner and said outer panels, said spacer strips being spaced being spaced inwardly relative to said end edges of said inner and outer panels panels whereby to define end junction channels between said inner and outer panels, said panels and said strips all being formed of polymer-modified fibre reinforced concrete material; and,

filling the spaces between said spacer strips and said inner and outer panels with synthetic plastic foam material.

14. A method of constructing walls, and a dwelling using wall structures having an inner rigid panel and an outer rigid panel of rectangular shape and defining length and breadth dimensions and defining side edges on either side and end edges on ends thereof said panels being spaced apart from one another, and a plurality of intermediate junction strips having a predetermined width secured between said inner and outer panels, and said junction strips having a length less than the length of said panels, and being arranged in parallel spaced apart relation, at spaced intervals between said inner and outer panels, and a plurality of end junction strips having a predetermined width equal to said intermediate junction strips secured between said inner and outer panels adjacent opposite side edges thereof, and spaced inwardly from said side edges whereby to define junction channels along said side edges between said inner and outer panels, a plurality of spacer strips having a predetermined width equal to the width of said junction strips and secured between said inner and outer panels transverse to said junction strips and adjacent thereto, said spacer strips being spaced inwardly relative to said end edges of said panels whereby to define end junction channels between said inner and outer panels, said panels and said strips all being formed of polymer-modified fibre reinforced concrete material; and, comprising the steps of;

erecting a plurality of said wall structures end to end to form dwelling walls ;

pouring concrete in said junction channels between adjacent said wall structures to secure the same together, and,

erecting a plurality of transverse structures spanning said walls and forming a floor, roof or the like.

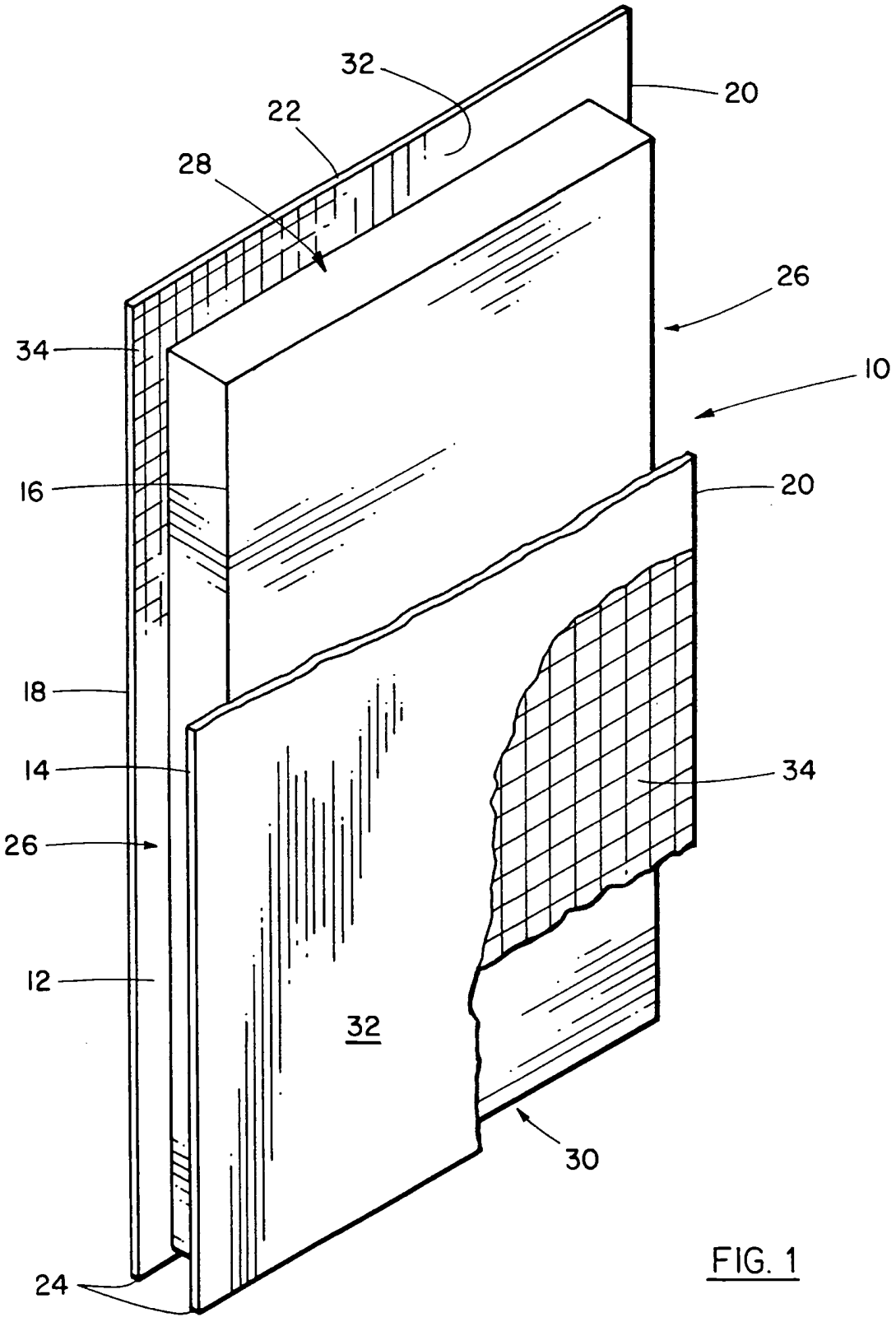

FIG. 1

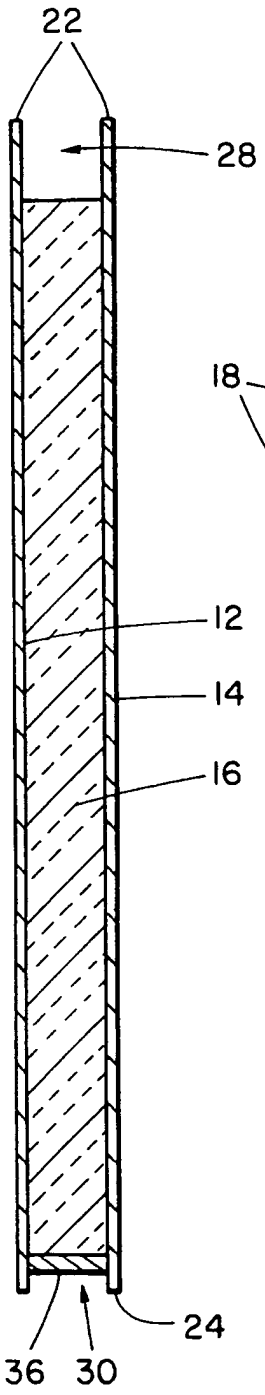

FIG. 2

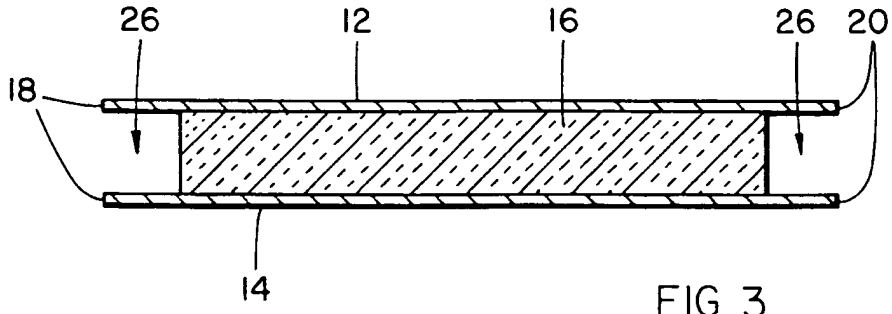

FIG. 3

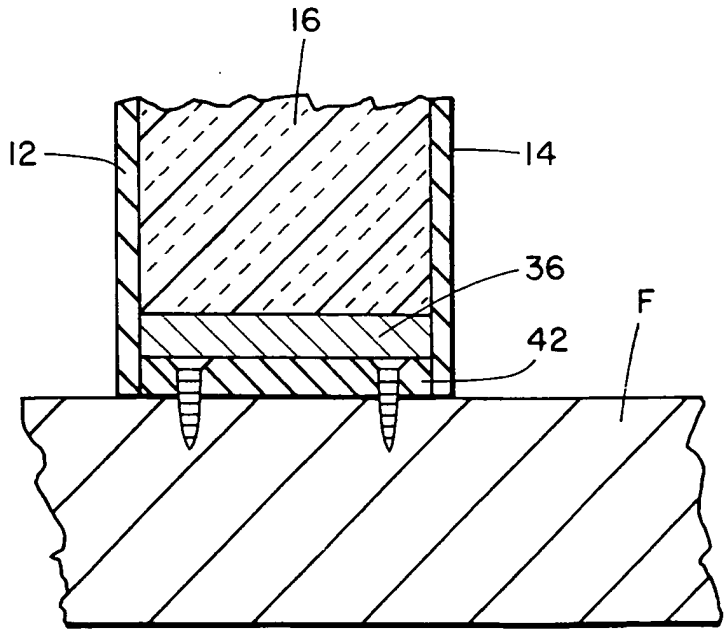

FIG. 5

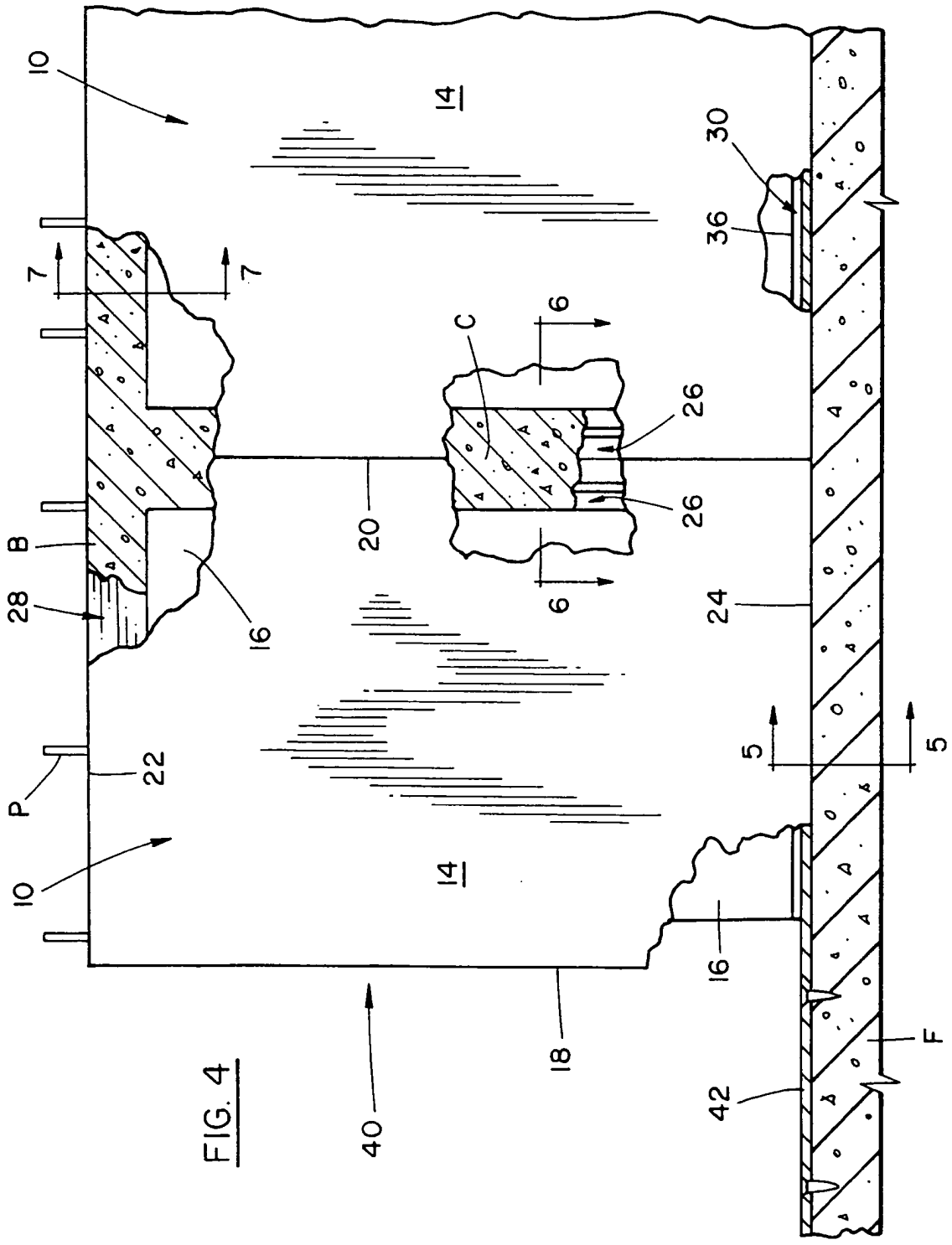

FIG. 4

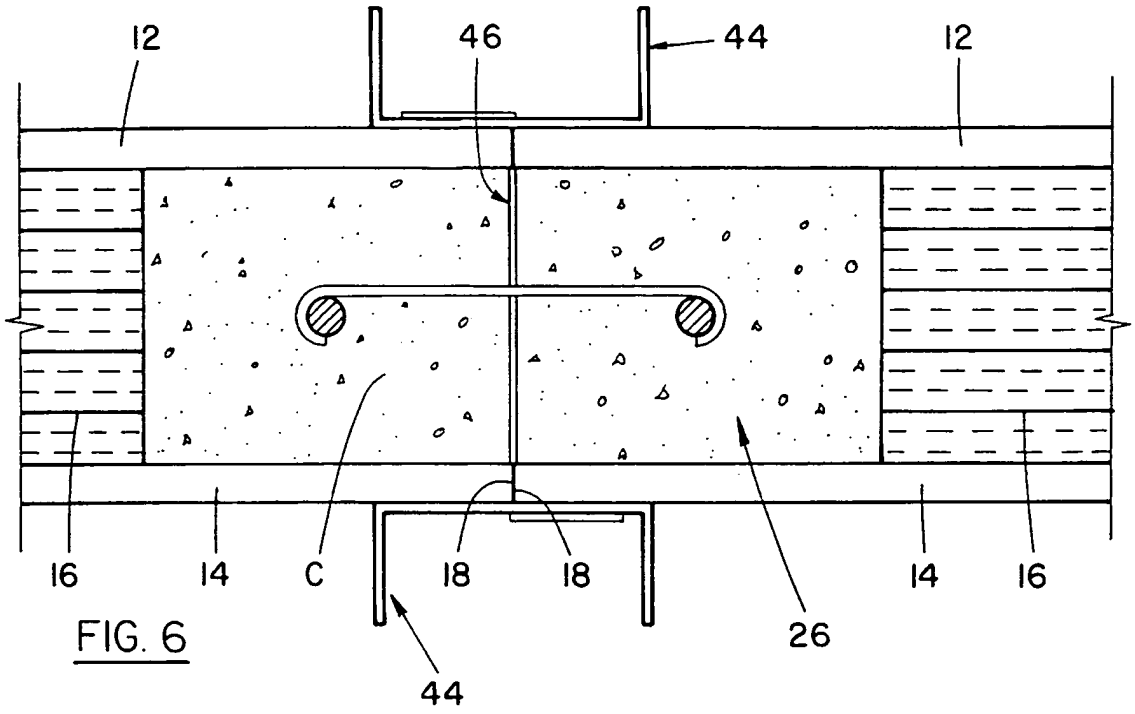

FIG. 6

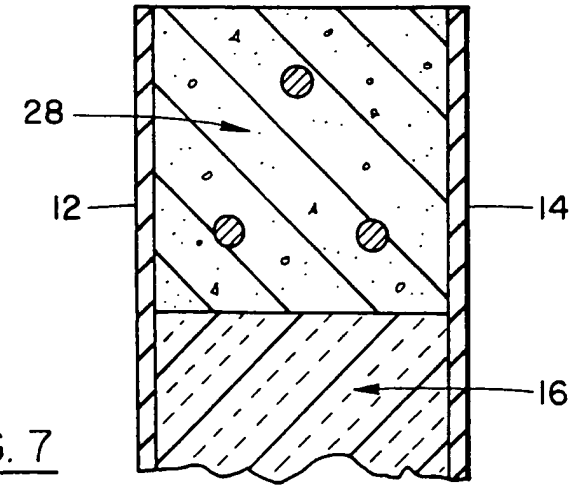

FIG. 7

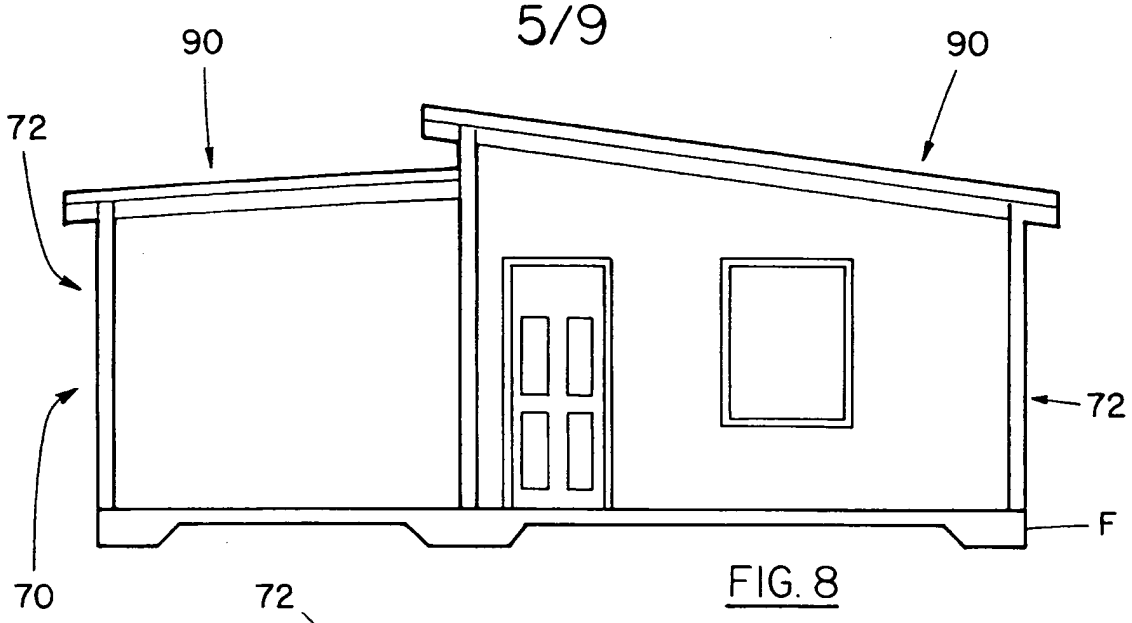

FIG. 8

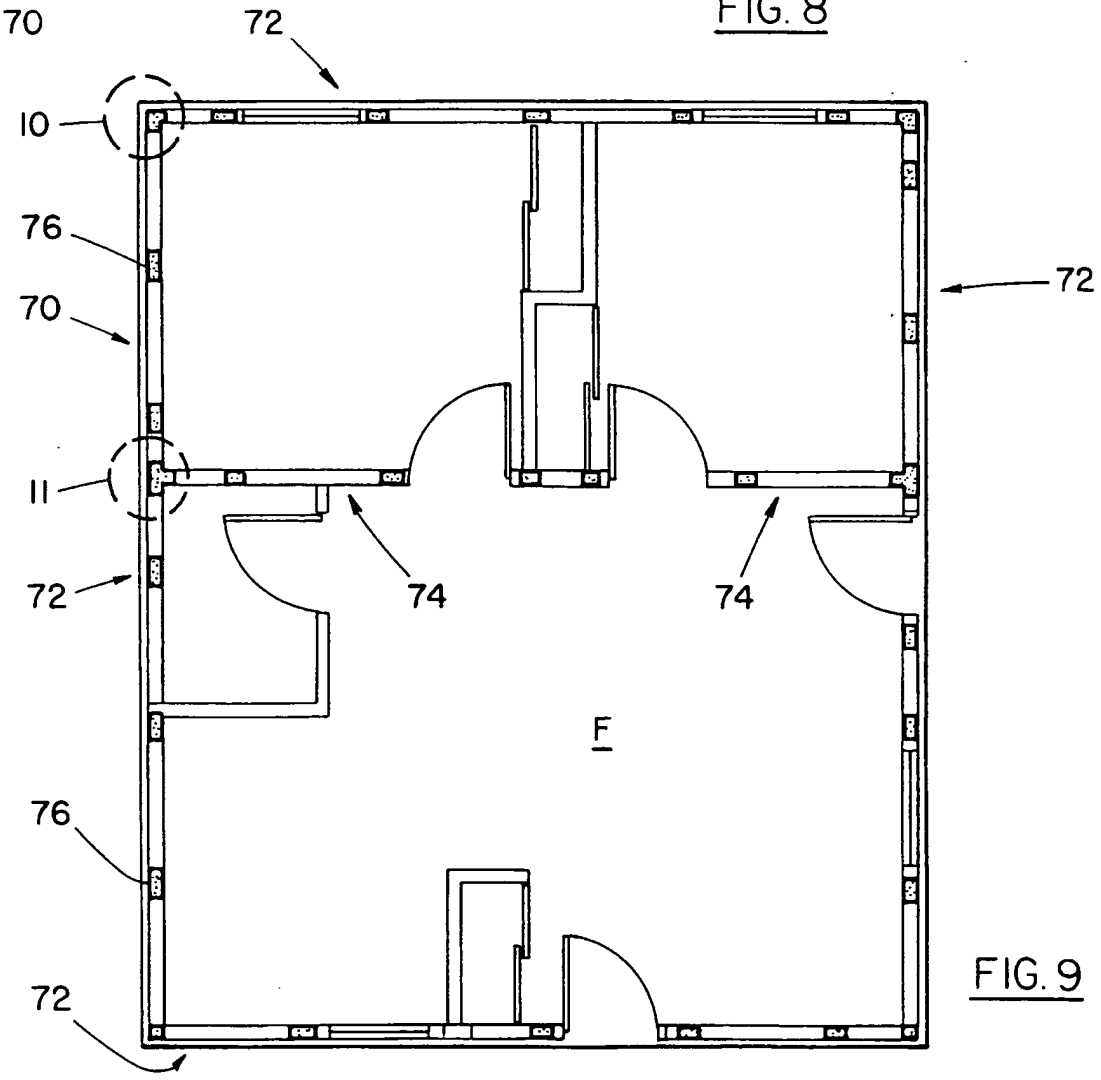

FIG. 9

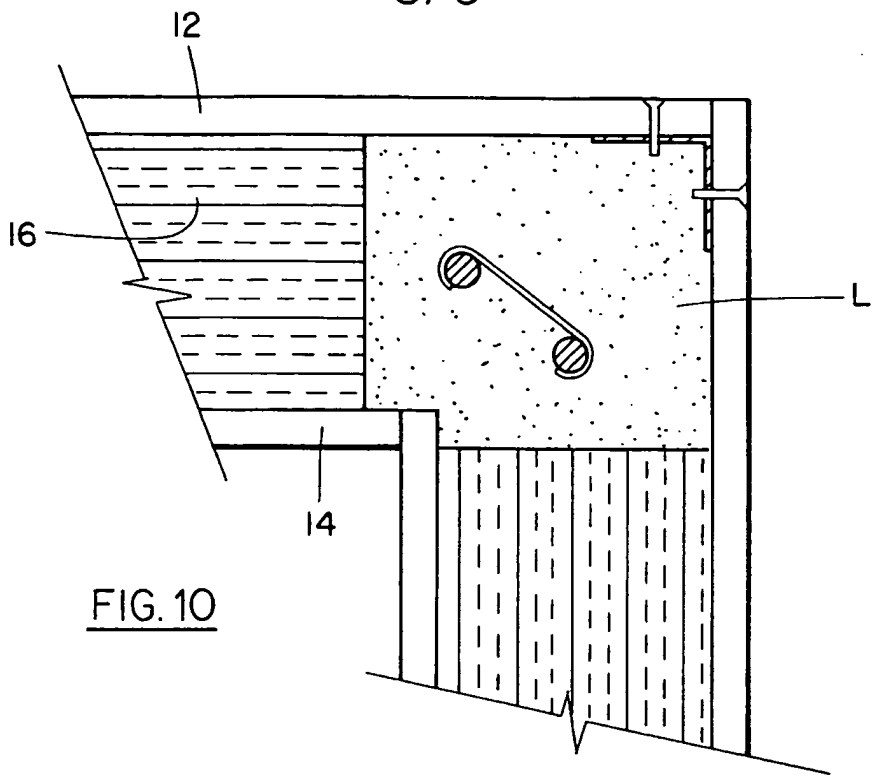

FIG. 10

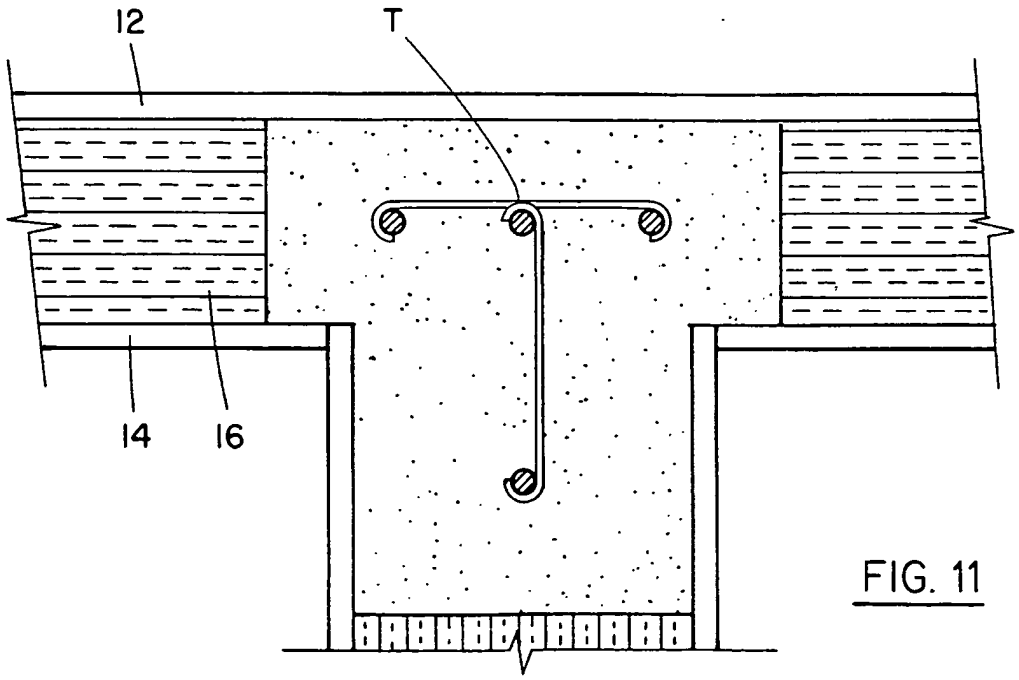

FIG. 11

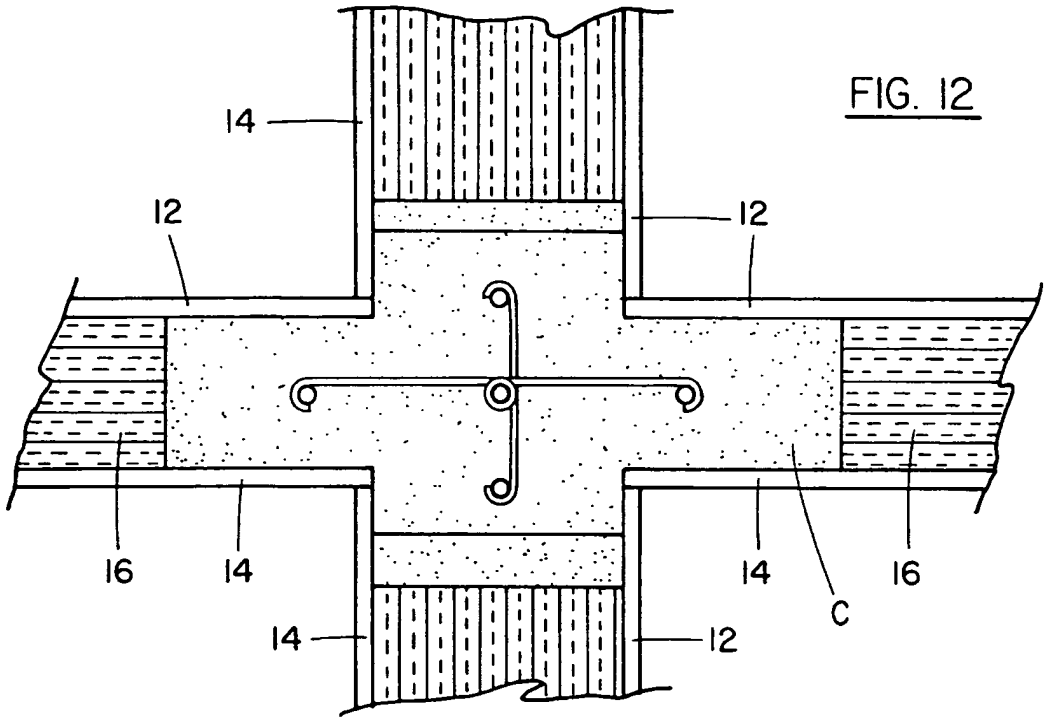

FIG. 12

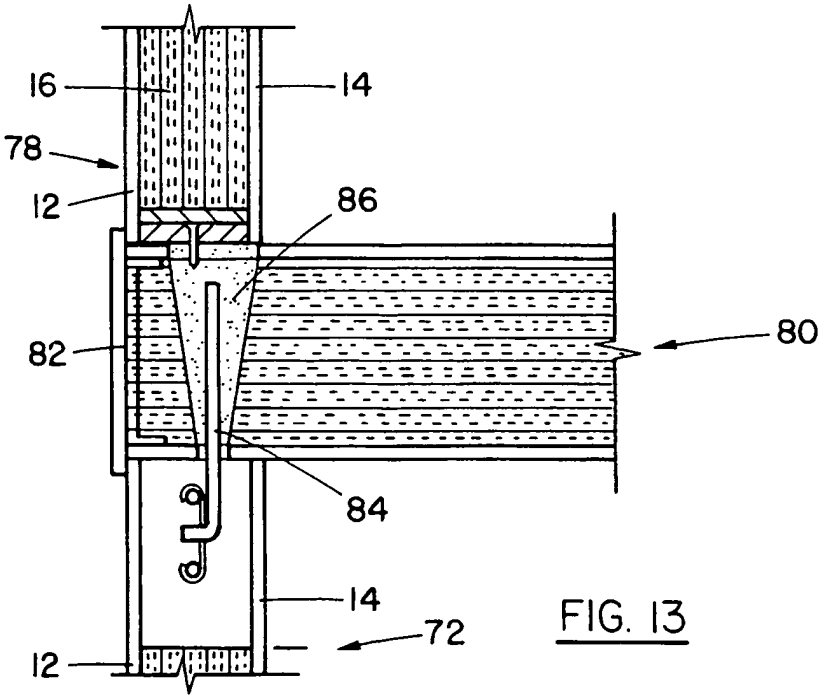

FIG. 13

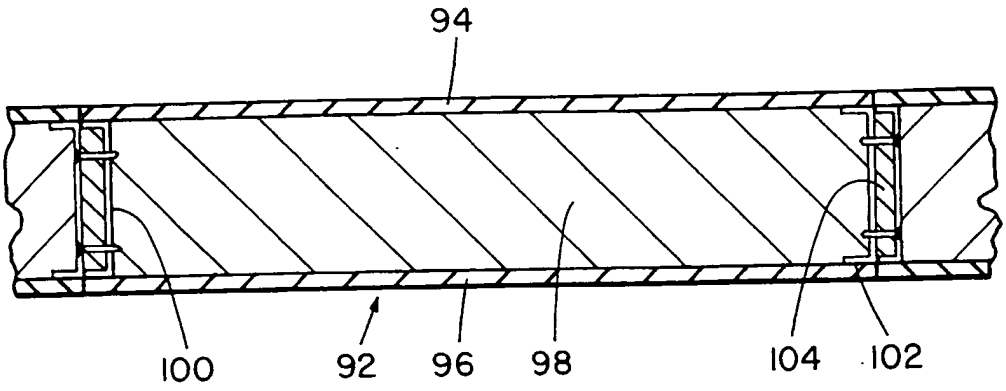

FIG. 14

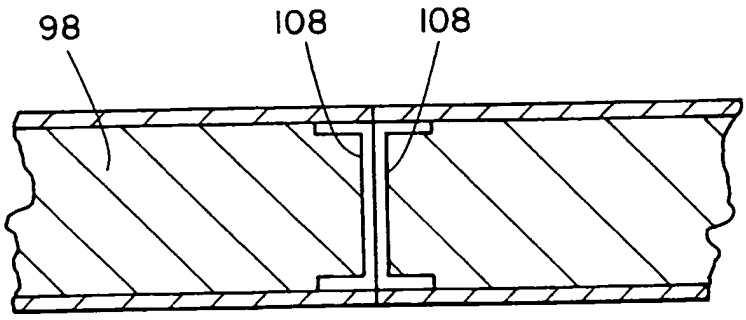

FIG. 15

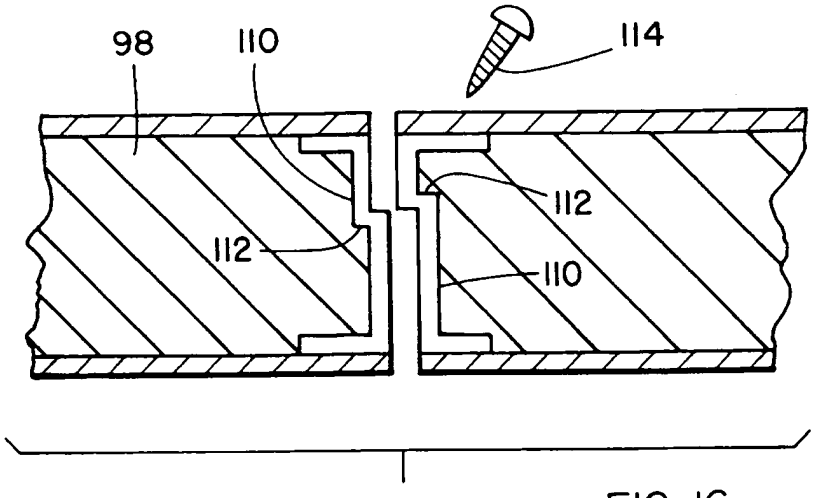

FIG. 16

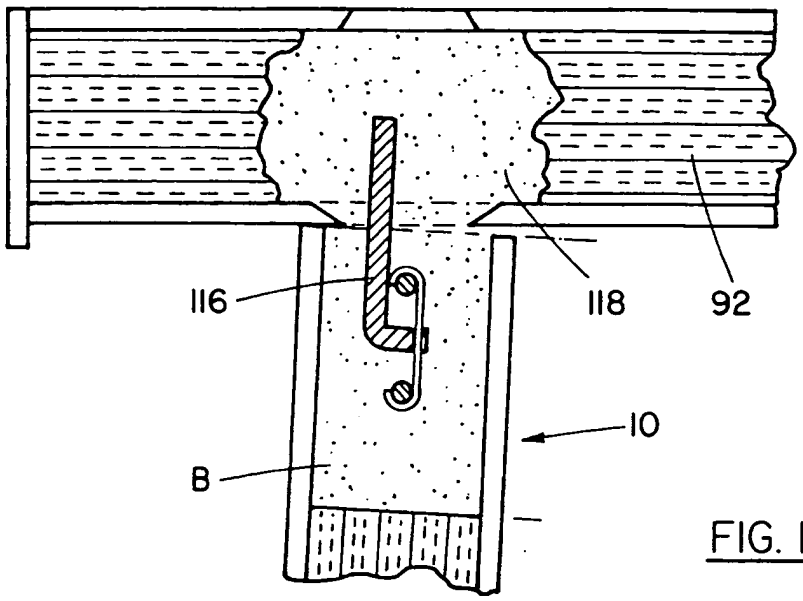

FIG. 17

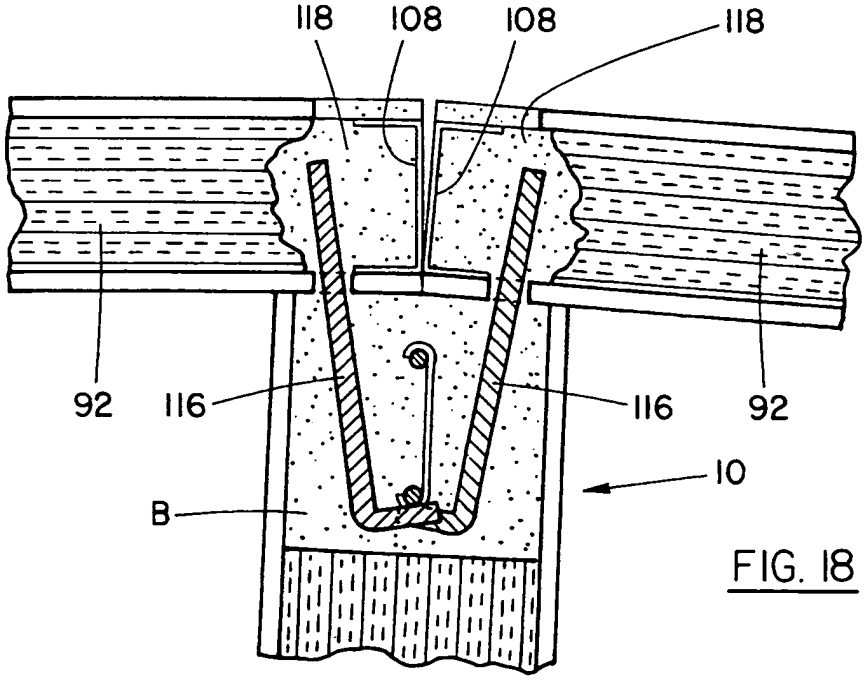

FIG. 18

INTERNATIONAL SEARCH REPORT

Inte ional Application No
PCI/CA 01/00381

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E04B2/86

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E04B E04C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 246 733 A (HABER TERRY M) 27 January 1981 (1981-01-27) the whole document	1-4,6,8, 13,14
A	WO 99 22086 A (KVAERNER PANEL SYS GMBH) 6 May 1999 (1999-05-06) the whole document	1,2,6-8, 13,14
A	US 6 006 480 A (ROOK JOHN G) 28 December 1999 (1999-12-28) the whole document	8,14

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 June 2001	09/07/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Vrugt, S

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte ional Application No
PCT/CA 01/00381

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4246733 A	27-01-1981	NONE	
WO 9922086 A	06-05-1999	DE 19747129 A	29-04-1999
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